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THE MEXICO CITY STRONG MOTION INSTRUMENTATION PROGRAM, FICA-LEG, STATE OF DEVELOPMENT

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SUMMARY

We have installed an array of twenty nine strong motion accelerographs to cover the Metropolitan Area of Mexico City and to some extent the lakebed Zone II of Xochimilco. State of the art solid state memory instruments with remote connection to a centralized computer using the Mexico City telephone lines have proven to be very reliable. The succesfull recording, at 22 sites of the 29 instrumented sites of the February 8, 1988 EQ., the data retrieval and its full process in a record time has tested and calibrated the capabilities of the FICA'S Strong Motion Program. The program is fully supported by the ICA Consortium of Construction Companies.

INTRODUCTION

The Mexican Consortium of Construction Companies, Grupo ICA, created the Fundación ICA, a non-profit civil organization, to promote and stimulate research in Seismic Engineering related problems. As a first major step, an array of twenty nine state of the art accelerometers has been installed and in full operation since November 1987. The array was installed and is operated jointly with CICESE, a research center funded by the Mexican Government through the National Council for Research and Technology, CONACYT.

The instruments are the FICA-leg of the Mexico City Strong Motion Array, comprised of: 40 instruments installed and operated by the Fundación Barros Sierra and; 29 instruments by FICA. The instruments, 69 total, have been installed in a dense array that provides a good coverage of the Mexico City Metropolitan Area in the lakebed zone, a sufficient coverage for the hard soils of the Western hills side of the city, and with a few recording sites in the lakebed zone II. The instrument locations are shown in the map (Figure 1) of the Mexico City soils deposits along with the main streets and avenues of the city. In this paper, we will describe the FICA-leg array of instruments, recent results from the records of the last February 8, 1988, Zihuatanejo Earthquake, and the underway future expansion of the array.

INSTRUMENTATION

General Description. The state of the art solid state Kinemetrics SSA-1 accelerographs were selected for the FICA'S instruments. The instruments incorporate recent advances in digital instrumentation technology with advantages of data accessibility, data volume, accurate timing, pre-event memory, trigger criteria, and microprocessor technology. The SSA-1 instrument interacts with the user by using a PC-Laptop portable computer saving the expense of a specialized, dedicated playback system.

The SSA-1 accelerographs have been installed at free field sites in a concrete vault partially buried in the soft soils of the city . Within the vault the accelerometer is tightly bolted at the center. A continuous power supply is provided by four globe cell 80 A/hr rechargeable batteries. In case of a power failure, the instruments can continuously operate on the external batteries for at least 20 days.

Installation procedures. The maximum sensitivity was adjusted to $\pm$ 1g. The 12 bits resolution of the SSA-1 A/D converter thus puts a limit to the range of values that can be measured to $\pm$ 1/2048 g to $\pm$ 1g . Recent recordings by 22 SSA-1 accelerographs of a magnitude 5.6 (Ms) earthquake located at the MAT in Zihuatanejo, show that earthquakes of this size and at this distance can generate maximum ground accelerations in the Mexico City lakebed of $\pm$ 4.9 X 10 -3g a factor of ten larger than the accelerographs threshold value.

The amplitude threshold event trigger criteria set to $\pm$4 digital counts in the hard soils sites and to $\pm$6 digital counts in the soft soil sites, along with the increased pre-event memory to a maximum allowed value of 15.36 secs and post event run time of 60 seconds has been satisfactory for recording ground acceleration time histories in the threshold limit set by the February 8, 1988 EQ. The SSA-1 trigger algorithm, based on a flexible voting scheme of the individual channels exceeding preset amplitude threshold values has been satisfactory for the past ten months of operation in terms of preventing spurious triggers.

THE ACCELEROGRAPH'S VAULT

Free field sites in Mexico City are restricted to school yards, parks and government backyards, that need special protection against vandalism and flooding. A concrete vault was designed to house the accelerometer, the batteries package, the telephone's modem, the connection for the WWVB time radio signal and the A.C. external power line for the batteries charger. A 25 pin serial port connector is currently being installed in an external switching box to operate the SSA-1 with a portable Laptop PC Zenith Z-183.

Dynamic response of the Vault: A complete description of the ground motion acceleration needs to be known within the frequency range of interest. The accelerometer's records provide a full description of the vault's motions. The free field motions need to be deconvolved from the vault's motion using some form of the soil-structure interaction transfer functions not presently known. As a first step we have to use numerical modeling to compute the vault's response within the frequency band of interest.

Soil structure interaction (Refs. 8, 9, 10) and high frequency scattering by the vault have a frequency dependent dominant effect. For the horizontal translation mode, at the vault's resonant frequency, the combined effect is to reduce damping as the ratio of embedment depth (H) to the vault's radius (R) decreases and the ratio of the vault's radius (R) to the vault's high (Δ) increases, (R/Δ). At higher frequencies filtering by scattering of the embeded vault dominates the response (E. Luco, personal communication). The maximum amplification factor Amax, increases as the ratio H/R decreases i.e. the soil-structure damping factor decreases with H/R. At zero embedment as the radius R of the vault increases Am·decreases and the vault behaves like a rigid soil layer. For a fix R/Δratio of 3.3, for example, as the embedment increases, Amax decreases slowly and remains within a value of 1.2.

In addition to the dynamic compensation of the vault's response by proper adjustment of the (H/R) and R/Δparameters, the vault's mass needs to compensate the mass of the removed soil, to mantain equilibrium. From the ratio Pc/Ps of the vault's concrete density Pc to the removed soil's density Ps for the range of soil density values in Mexico City as a function of theΔ/H parameter and a given value of Amax of 1.2, we have: R/Δ=3.3 and we can choose H/R=0.8 thusΔ/H~0.4, and the vault is expected to be at most 50% heavier than the removed soil.

STANDARD PROCESSING OF THE ACCELEROGRAMS DATA FILES

Caltech's Volume I, II and III standard process of the data files, is performed using a PC-Laptop Zenith 183 with 640 RAM and 20 MB hard disk and a 8-Pen HP-7550A graphics plotter. The typical 200 secs. 3-channels SCT accelerogram Volume III process for 100 periods and 5 damping values takes 90 mins with the Z-183, Volume II process takes 360 mins. Integration of the accelerograms requires good judgement and analysis by well trained strong motion data analysts to determine the frequency limits for band pass filtering for integration.

RECENT RESULTS

The recent February 8, 1988, earthquake ground motion recordings at 22 of the 29 instruments installed, provided a unique opportunity to test and calibrate the over-all system. Within the next two days all of the stations were visited and 22 3-component accelerograms were collected. Volume I, II and III processes take one week for the full computations and plotting, using two of the FICA'S Z-183 PC-Laptop. The 22 raw and processed accelerograms are storaged in high density (1.2 MB) 5 1/4 floppy disks and in magnetic tape. The raw data is stored in three floppy disks. Volume I and II in twenty two floppy disks each.

Peak ground acceleration in the lakebed of Mexico City did not exceed 0.01g. Stations located at the hard soil hills did not record the event because the ground motions were below the 0.004g threshold value of the instruments. Reduction of the maximum sensitivity of the force balance accelerometer to $\pm$0.5g has been considered of little value.

In Figures 2 for comparison we show the NS components of the SCT, Sept 19, 1985 Michoacan EQ. and the San Simon (SI) February 8, 1988 records, at a nearby site. The response spectra for sites in the vicinity of SCT (Stations VM29, BA49 and SI53) shown in figures 3 have dominant periods from 1 to 1.6 secs in contrast to the strong 2 secs dominant period at SCT.

The contour plots of absolute acceleration response spectra dominant periods shown in figures 1 show that for this earthquake, dominant periods change rapidly in the north and north-east zone of Mexico City. As we move from the lakebed sediments to the hard soils the period changes from a minimum of 0.6 secs to 1.4 secs at the edges of the transition zone. A similar effect is observed to the south edge of the transition zone.

Because the amplitudes observed during this earthquake were at threshold of the instrument resolution the absolute acceleration response spectra results, need to be considered marginal, but illustrates the kind of results to be expected and the variability in amplitudes and dominant periods of the response of the Mexico City lakebed for a given earthquake size and epicentral distance.

DISCUSSION AND FUTURE EXPANSION OF THE ARRAY

The Mexico City strong motion array, FICA'S-leg, was installed and set in full operation in a record time of twelve months. That includes: purchase of the instruments and deliver to Mexico City FICA'S-leg office, construction of the accelerometers vault, installation of the instruments, including antennas for the WWVB radios A.C. power and telephone lines (six sites); and most important, the calibration of the system by the successful recordings of the February 8, 1988 earthquake.

Records of earthquakes of magnitude larger than 6 are required to improved resolution of the response spectra amplitudes and dominant periods. Additional instruments are required to provide a good coverage in the lakebed Zone II of Xochimilco, and to the eastern part of the city, Ixtapalapa. Two in the lakebed itself and two in the hard soils. At least the SCT, CDA and TAC sites should be included in the study of proposed sites.

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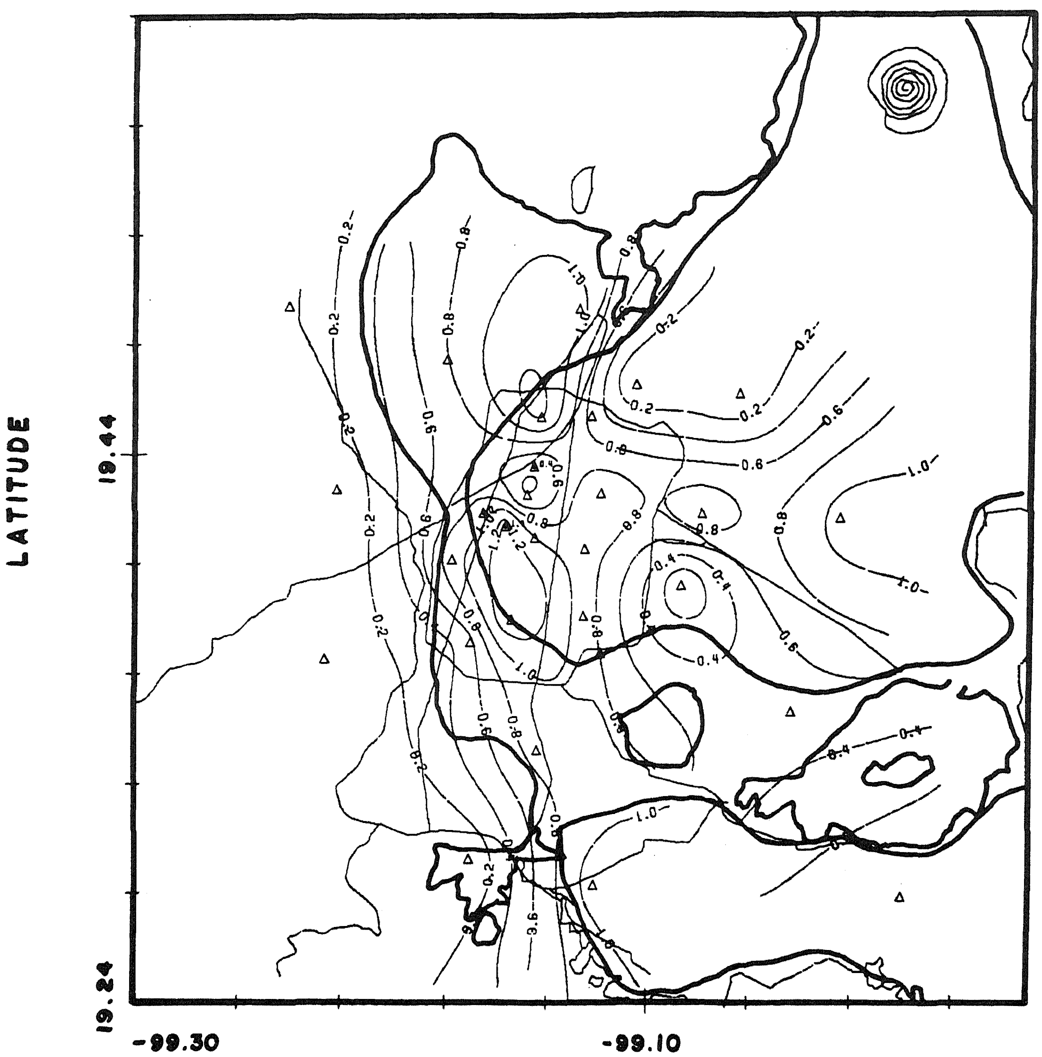

FIGURE 1 LONGITUDE

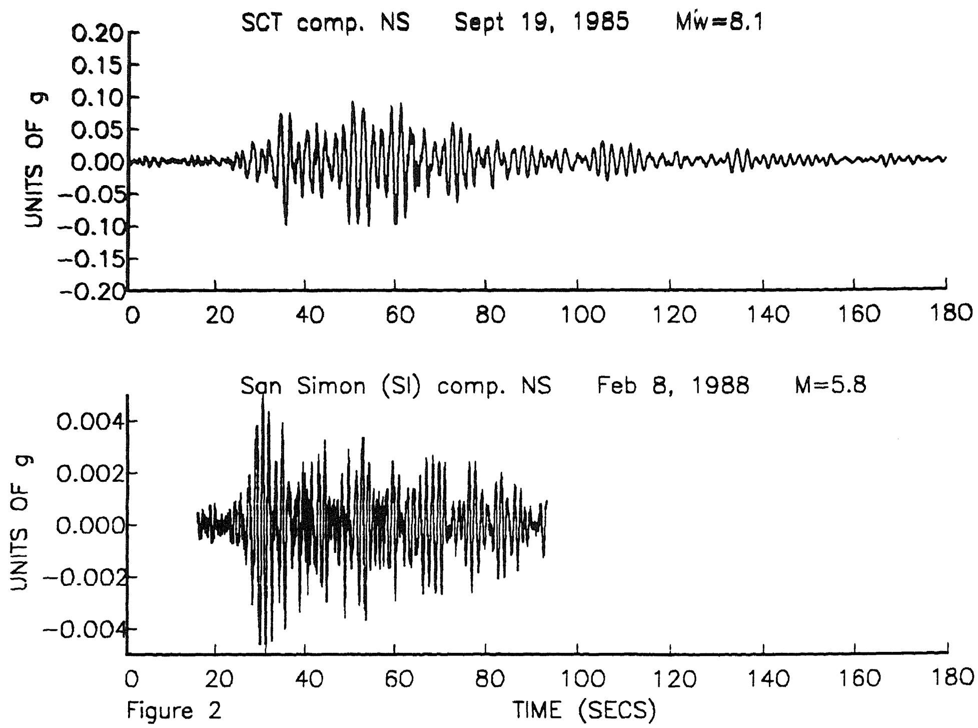

Figure 2

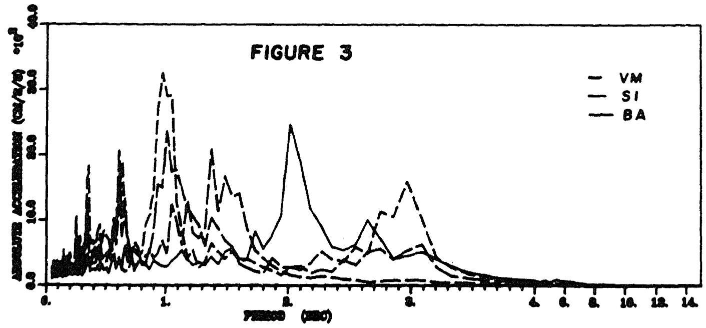

FIGURE 3